(219) Sandstone, olive-gray, fine-grained, thin-bedded but weathers

massive, quartz— and chert—rich "salt—and—pepper.

(218) Mudstone, olive-green.

(104) Sandstone, olive-gray, medium-grained, thin-bedded, moderately

calcareous, quartz- and chert-rich "salt-and-pepper."

Any use of trade names in this publication is for

descriptive purposes only and does not imply

endorsement by the U.S. Geological Survey

MADISON RANGE COMPOSITE SECTION PAMPHLET ACCOMPANIES MAP BIG SKY SECTION Upper part of Madison Range composite section RUBY RIVER SECTION SE1/4 sec. 28 and SW1/8 sec. 27, T. 6 S., R. 3 E., and NE1/4 sec. 16, T. 9 S., R. 3 W., Home Park Ranch 7.5-minute quadrangle, and (217) Mudstone, dark-gray. (102) Sandstone, gray to olive-gray, fine-grained, clayey, biotitic, NW1/4 sec. 34, T. 7 S., R. 3 E., Gallatin Peak 7.5-minute quadrangle, NW1/4SW1/4SE1/4 sec. 17, NE1/4 sec. 20, SW1/4SW1/4 sec. 21, T. 9 S., R. 3 W., noncalcareous; ripple crossbeds; contains plant fragments, (216) Mudstone, olive-green. Madison Range, Gallatin County, Montana. Varney 15-minute quadrangle, Greenhorn Range, Madison County, Montana. including twigs and small logs; mudchips. 101B (101) Mudstone and sandstone, interbedded. Mudstone, gray, 60 percent of unit. Sandstone, olive-gray, fine-grained to very fine IDENTIFICATION FEET/METERS LITHOLOGY DESCRIPTION grained, thin-bedded, carbonaceous, calcareous; locally burrowed; FEET/METERS ı ı 1950 — IDENTIFICATION LITHOLOGY 1 1 1 1 (211) Sandstone, light-gray in upper part and olive-gray in lower part; fine-grained, thin-bedded, calcareous, quartz- and chert-rich; (54) Mudstone and sandstone, interbedded. Mudstone, dark—gray, thin plant fragments in lower part; trough crossbed axes strike 160*-190*. D12918> (319) Sandstone and mudstone, interbedded. Sandstone, medium-gray, (100) Sandstone, olive-gray, fine-grained, one bed, muddy and rubbly (209) Mudstone, olive-green. medium-grained, thin-bedded. Mudstone, olive-green, poorly exposed. in upper part. feldspar; locally calcareous; plane bedded and local ripples and broad 1975 trough crossbeds. Abundant discontinuous beds a few cm thick of (206) Mudstone, dark-gray; local lenses of medium-gray limestone with (98) Sandstone. Upper part is olive-gray, fine-grained, clayey, dark-gray mudstone and clayey siltstone. Lower part contains thin 1 1 1 1 1 1 1 1 1 1 1 1 1 gastropods, and dark-brown fetid limestone with leaf imprints. carbonaceous. Middle part is light-gray, fine-grained, composed of interlayers of horizontal pale-brown mudstone between ripple-(205) Sandstone, light-gray, thin- to medium-bedded, weathers laminated sandstone. Chert pebble conglomerate locally at base. quartz, chert, and feldspar; contains minor plant debris. Lower massive; noncalcareous, composed mainly of quartz and some chert. part is olive-gray, weathers rusty brown, fine- to medium-grained, (48) Siltstone and Mudstone, thin interbeds, carbonaceous. Upper part is plane bedded; some beds contain root structures in noncalcareous, composed of quartz, chert, and feldspar; growth position. Lower part is trough crossbedded; contains local thick-bedded; contains abundant plant debris, including twigs, (47) Sandstone, medium— to dark—gray, fine— to medium—grained, (317) Sandstone, medium-gray, fine-grained, quartz- and chert-rich thin- to medium-bedded, quartz- and chert-rich; local mud chips; asymmetrical ripples that show transport was from west to east. branches 20-30 cm long and 7-8 cm in diameter. "salt-and-pepper," thin-bedded; load structures at base; contains 203A (92) Sandstone, olive-gray, fine-grained, thin-bedded, burrowed; Unit is erosional into underlying strata, and is lenticular along , , , 2000 clayey; burrowed locally. pieces of carbonized wood. 1 1 1 1 contains plant fragments, leaf impressions, twigs; tops of beds are (204) Mudstone and sandstone, interbedded. Mudstone, gray. Sandstone, muddy and biotitic; ripple crossbedded. (46-28) Mudstone, siltstone, and tuff, interbedded, thin-bedded, in 1111 50-1 1 1 1 olive-gray, fine-grained, 1- to 15-cm-thick beds, clayey, units as much as 1 m thick. Mudstone, dark-gray, noncalcareous, D12920 (91) Coal, clayey. carbonaceous plant debris; locally coaly. Siltstone, dark-gray, (314) Mudstone, olive-green. carbonaceous, rubbly weathering. (90) Mudstone, olive-green. carbonaceous, local small—scale ripple crossbeds; megafossils (89) Mudstone, dark-gray, carbonaceous. locally. Tuff, yellowish-green, yellowish-orange, light-gray, (313) Sandstone, olive-green, fine-grained, noncalcareous, thincommonly deeply weathered, bentonitic; some beds hard, dense, (88) Mudstone, olive-green, carbonaceous. (202) Sandstone, light-gray, weathers brownish gray to brown, bedded, trough crossbeds. finely laminated, graded, silicified, contain lithophysae. (87) Mudstone, dark-gray, coaly. D12919**>**→ medium-grained, medium-bedded, very calcareous, micaceous, (86) Sandstone, olive-gray, fine-grained, thin-bedded, moderately quartz— and chert—rich; horizontal burrows; some wood fragments. (312) Mudstone, olive-green. calcareous; tops of beds are clayey, biotitic, contain plant debris. 85-84 Some stems are vertical, in growth position.
(83) Sandstone, olive-gray, fine-grained, clayey, thin-bedded. (27) Sandstone, dark-gray, fine- to medium-grained, thin-bedded; rippled. Tops of beds are clayey, biotitic, contain plant fragments; mostly angular quartz grains, but 15-20 percent rounded; clayey, carbonaceous; upper part has carbonized plant stems. (81) Sandstone, olive-gray, fine-grained, clayey in upper part. (26) Sandstone, pale-brown, fine- to medium-grained, massive. Upper 0.0-2 m, light-gray, medium-grained, noncalcareous, quartz-rich (200) Sandstone, in beds 10-20 cm thick, except for one 1-m-thick 1 | 2050 — 6251 | 1 (307) Sandstone, medium-gray, weathers brown, fine-grained, 1- to 2bed. Upper part is medium-gray, weathers brownish gray, sandstone, minor plant debris. Irregular erosion surface at top. 1 1 1 100 — | 1 1 1 1 cm-thick wavy beds, quartz- and chert-rich "salt-and-pepper." medium-grained, quartz— and chert-rich "salt-and-pepper;" · | | 100 crossbedded. Lower part is olive-gray, rubbly. (79) Sandstone, olive-gray, fine-grained, noncalcareous, upper part (25) Sandstone, yellowish—gray, fine— to medium—grained, locally coarse—grained and pebbly, thin— to medium—bedded; a few hummocky (198) Covered. Change in dip. Small fault concealed here? crossbeds in lower part, trough crossbeds in upper part; local carbonaceous shale lenses a few mm thick; local burrows. 196B (300) Sandstone, olive-brown, fine-grained, thin-bedded. (196) Mudstone, minor sandstone, olive-green, poorly exposed. (77) Sandstone, medium-gray, fine-grained, 10- to 50-cm-thick beds, (299) Mudstone, dark-gray, weathers into chips. very calcareous, quartz-and chert-rich, "salt-and-pepper;" biotitic (24) Siltstone, Mudstone, and Sandstone, rhythmically interbedded; and clayey in upper part; a few small burrows. Sharp lower contact. dark-gray, thin-bedded, finely laminated; mainly plane bedded but some ripple crossbeds; a few horizontal burrows on mudstone beds, a (76) Mudstone and sandstone, interbedded in intervals as much as few vertical burrows in siltstone and sandstone. ı ı 2100 — 20 cm thick; mudstone is 70 percent of unit and contains many wood ,,,,150— ,,,, 1125fragments. Three lithic types are repeated several times—from top to (23) Siltstone, dark-gray, thin-bedded; minor mudstone, sandstone; 1 1 1 1 1 150 1 1 1 1 bottom: olive-green mudstone, dark-gray mudstone, olive-gray finegrained sandstone. Sandstone contains local ripple crossbeds. (22) Sandstone, yellowish-gray, fine-grained, medium-bedded to (75) Sandstone, medium-gray, fine- to medium-grained, beds 0.5—1 m massive; hummocky crossbedded, plane beds in upper 1 m. thick: contains plant debris; guartz- and chert-rich "salt-and-(192) Sandstone, dark-brown-weathering, fine-grained to very fine pepper;" muddy and biototic in uppermost part; a few trough grained, ripple crossbedded; basal few centimeters argillaceous and crossbeds, wavelength about 1 m. Local soft—sediment deformation. contain whole leaves. Top of unit contains megaripples with axial 1 1150trend of 160°, transport toward 012°. (74) Sandstone to siltstone, and mudstone, interbedded. Sandstone (21) Sandstone and Mudstone, dark-gray to olive-gray. Sandstone, to siltstone, olive-gray, fine-grained, thin- to medium-bedded. very fine grained to fine-grained, well-sorted; hummocky crossbeds; (191) Mudstone, and sandstone to siltstone, interbedded. Mudstone, Beds pinch and swell along strike; one is lenticular, scoured into Ophiomorpha burrows at steep angle to bedding. Local ball—and olive-green, makes up most of unit. Minor interbedded olive-gray underlying strata of unit. Mudstone is olive-gray, carbonaceous. pillow structures. Mudstone about 50 percent of unit. siltstone to very fine grained sandstone, thin-bedded. (294) Sandstone, olive-green, fine-grained, thin-bedded, poorly (73) Covered. Calcite chips; change in dip of beds on opposite sides of interval; could be fault here, probably minor. ı ı 2150 — (70) Mudstone, olive-green, some carbonaceous debris; forms chips. (20) Mudstone, dark-gray, thin-bedded, finely laminated, 1 1 200 1175 — (69) Mudstone, gray, carbonaceous. (19) Sandstone and siltstone, dark-gray, thin-bedded, weathers massive and rubbly; finely laminated; discontinuous mudstone (66) Coal, clayey, sheared. laminae and 1- to 2-cm-thick sandstone lenses; unit bioturbated. (190) Mudstone, dark-gray, carbonaceous. (65) Mudstone, olive-green to gray; plant debris in upper part. (18) Sandstone, medium-gray, fine-grained, massive, clayey, (64) Sandstone, medium-gray, fine-grained, moderately calcareous, carbonaceous; fossil debris; Ophiomorpha burrows at steep angle to "salt-and-pepper;" beds 1-2 cm thick; trough crossbeds upper 50 cm. D11923,4**>>→**∭ (189) Mudstone, and sandstone to siltstone, interbedded. Mudstone, 2175---(63) Siltstone, gray, muddy, oscillatory ripple marks. bedding in upper part. olive-green, makes up most of unit. Minor interbedded olive-gray siltstone to very fine grained sandstone, thin-bedded. ,,,1200— ,,,, (17) Sandstone, medium-gray, fine-grained, thin-bedded, hummocky (62) Mudstone, dark-gray, silty, finely laminated. crossbeds: contains thin lenses of siltstone and mudstone. (61) Sandstone, gray, "salt—and—pepper," poorly exposed. dark-gray, carbonaceous. (16) Sandstone, yellowish-gray, fine-grained, finely laminated, (185) Sandstone, medium-gray, fine-grained, quartz- and chert-rich hummocky crossbeds, local ripple crossbeds; sparse clayey sandstone (292) Sandstone, medium-gray, medium- to coarse-grained, thick-"salt-and-pepper;" trough crossbedded, axial trend of 160°. Minor 185 interbeds. Ophiomorpha burrows at steep angle to bedding. , , , , 2200 bedded, noncalcareous, quartz— and chert—rich "salt—and—pepper." interbedded mudstone, olive-green. 1111 1 1 250 — 1 1 1 1 1225 ---(184) Mudstone, minor sandstone, olive-gray. Sandstone, very fine **├** 375 (291) Mudstone, olive-green, weathers into chips. 675 (290) Sandstone, olive-gray, 1- to 2-cm-thick beds. (183) Sandstone, 1-cm-thick beds, rippled; upper part olive-gray, (15) Mudstone, dark-gray, thin-bedded, minor interbedded sandstone, muddy; lower part, light-gray-brown, very calcareous. and a few thin tuff beds. (288) Mudstone, olive-green. 2225 --- (287) Sandstone, olive-gray, 1— to 2-cm-thick beds. EXPLANATION OF MEASURED SECTIONS (182) Mudstone, dark-gray, carbonaceous, locally coaly. About 20 (286) Mudstone, olive-green, minor interbedded sandstone, olive-(14) Siltstone, dark-gray, medium-bedded; a few discontinuous whispy percent of unit is 20- to 30-cm-thick interbeds of olive-gray, finegray, 1— to 2—cm—thick beds. (285) Sandstone, olive—gray, 1— to 2—cm—thick beds. sandstone layers, dark-gray, fine-grained, medium-bedded: and grained, silty, weakly calcareous, "salt—and—pepper" sandstone. discontinuous light-gray tuff beds a few centimeters thick. (58) Sandstone and mudstone, interbedded. Sandstone, medium-gray, FEET/METERS² LITHOLOGY³ (284) Mudstone, olive-green; minor interbedded sandstone, olive-IDENTIFICATION 1 very fine grained, 10- to 15-cm-thick beds, finely laminated, 1111 calcareous, "salt-and-pepper," well-cemented; 70 percent of unit. (283) Sandstone, olive-gray. 111 300-(13) Siltstone and mudstone, dark-gray, thin- to medium-bedded, ripple 1111 1275 — Mudstone, olive-green, carbonaceous. — Sill, granitic crosslaminated. Mudstone layers discontinuous. Sharp upper contact. (57) Mudstone, olive-green, carbonaceous. (56) Sandstone, pale-yellowish-orange, limonitic, fine-grained; (12) Tuff, light-gray, weathers chalky; sharp lower contact. - Conglomerate, clast-supported coaly stems in growth position. (11) Siltstone and mudstone, medium-gray, thin-bedded, massive (55) Siltstone, dark-gray, thin-bedded, slightly calcareous. weathering; mudstone layers are discontinuous, whispy; bioturbated. - Sandstone, massive (54) Mudstone, olive-green. 2275 --(180) Mudstone, olive-green. (53) Coal, clayey. (9) Siltstone and sandstone, dark—gray, thin—bedded, finely laminated. 1 1 1 1 300 - Sandstone, horizontal laminations (179) Sandstone, olive-gray, very fine grained, 2- to 3-cm-thick, 1 1 1 1 (48) Coal, clayey. (8) Sandstone, yellowish-gray, fine- to medium-grained, massive, — 100 beds, mud chips and wood fragments present. (47) Mudstone, olive-green. bioturbated; a few Ophiomorpha burrows at high angle to bedding; (178) Mudstone, olive-green, poorly exposed. -Sandstone, ripple layering upper 20 cm muddy. (46) Sandstone, fine-grained, beds 10-25 cm thick, local thin interlayers of siltstone and mudstone, plant debris. Upper 1 m is (7) Mudstone, dark-gray, silty, thin-bedded. (176) Mudstone and sandstone, interbedded. Mudstone makes up 80 (281) Sandstone, fine-grained, thin-bedded, quartz- and chert-rich. -Sandstone, trough crossbeds or dark-gray, massive, rubbly weathering, noncalcareous, biotite-rich. percent of unit, olive-green, poorly exposed. Sandstone, rusty-(6) Sandstone, yellowish—gray, fine—grained in lower part and medium— (280) Mudstone, gray, weathers into chips, poorly exposed. Middle part of unit contains asymmetrical ripple marks; local hummocky crossbeds brown, fine-grained, thin-bedded, moderately calcareous. grained in upper part, finely laminated, massive; hummocky 1 1 2300 1111 50 - 1111 horizontal burrows on bedding surfaces. (45) Mudstone, dark—gray, abundant plant debris (279) Sandstone, olive, fine-grained, quartz— and chert-rich 176C ı ı 350 — Limestone, micritic, crystalline 1325 -1 1 1 1 1 | 1 | 350 --- | | | | | | | (5) Sandstone, yellowish-gray, fine-grained, thin planar beds. "salt-and-pepper," 15-cm-thick beds. or coquina (44) Mudstone, olive-gray to gray, carbonaceous. (175) Sandstone, olive-gray, fine-grained, rubbly, thin-bedded, - Siltstone or clayey siltstone; may (43) Sandstone, fine-grained, thin-bedded, rubbly, mudcracks. noncalcareous, well-comented, quartz- and chert-rich "salt-D6806> be massive, contain horizontal (42) Mudstone, dark-gray, carbonaceous. and-pepper;" contains a few wood impressions several centimeters laminations or ripples in diameter; base is undulatory. (41) Mudstone, olive-green, carbonaceous. (3) Sandstone, yellowish-gray, thick-bedded, very finely laminated, local whispy clay layers; local ripple crosslaminae; a few small mud (40) Coal, sheared. - Coal or clayey coal (39) Mudstone, olive—green, carbonaceous. (2) Sandstone, yellowish-gray, very fine grained, medium-bedded. (38) Siltstone, olive-gray, thin-bedded, clayey, carbonaceous. . , , , 1350 fine irregular laminae; some ripple crosslaminae. Shale, weakly to strongly fissile (36) Mudstone, olive-green, carbonaceous. (277) Sandstone, medium-gray, medium- to coarse-grained, thick---- Mudstone (35) Sandstone, olive-gray, very fine grained, thin-bedded. bedded, calcareous, quartz- and chert-rich "salt-and-pepper. (34) Mudstone, olive-green to dark-gray, carbonaceous. (173) Sandstone, light-gray, fine-grained, thin-bedded, composed Mudstone, porcellanitic (33) Sandstone, olive-gray, fine-grained, clayey, rubbly slightly. mainly of quartz and 10-20 percent gray chert. Massive. ı ı ı ı 2350 - - 1111 calcareous; stems (3 mm diameter) in growth position; bedding surfaces ,,,400— 1375 — 400 — are mudcracked and coated with biotite flakes and coaly debris; beds Mudstone, carbonaceous to coaly are lenticular. (32) Mudstone, olive, except gray in upper 20 cm where plant (171) Sandstone, medium-gray, weathers dark brown, fine- to mediumgrained, noncalcareous, poorly cemented, "salt-and-pepper," mainly remains are abundant. quartz, chert, and feldspar; trough crossbedded. Plant debris (31) Sandstone, olive-gray, fine-grained, thin-bedded; middle third present throughout; lower part has branches, twigs, and mudchips. weathers dark brown due to coaly debris; ripple marks. ---- Bentonite (30) Mudstone, olive-green; minor fine-grained sandstone. (170) Sandstone, medium-gray, coarse-grained and locally pebbly, (29) Sandstone, gray-green, fine-grained, thin-bedded, calcareous, one thick bed, quartz— and chert—rich "salt—and—pepper;" trough _____ Covered interval 1 1 1 1 400 crosslaminated in lower part; base eroded into underlying unit (28) Mudstone, olive-gray, abundant carbonaceous debris. MADISON RANGE COMPOSITE SECTION (169) Mudstone, gray, carbonaceous, weathers into chips. LINCOLN MOUNTAIN SECTION ¹Numbers shown in this column of the sections are lithologic unit Lower part of Madison Range composite section numbers. They are in sequence, with the largest number representing the NW1/4 sec. 7, T. 9 S., R. 4 E., Lincoln Mountain 7.5-minute quadrangle, 1 1 1 2400 --youngest or uppermost unit. Some unit numbers are repeated, reflecting 1 1 1 1 Madison Range, Gallatin County, Montana. subdivision of the lithologic unit so that the computer would show different 1425 — 1 1 1 450 — 1 1 1 1 SAMPLE . lithologies within the unit. FEET/METERS LITHOLOGY IDENTIFICATION ²Each section is displayed as a borehole with increasing depth down (35) Sandstone and mudstone, interbedded. Mudstone, dark-gray, thinsection, in feet and meters. Data are presented at a scale of 1 in. = 25 to medium-bedded. Sandstone, olive-green to gray-green, fine- to ft. Graphic resolution for individual beds at this scale is 1.25 ft (beds medium-grained and locally coarse-grained, thin— to medium-bedded; composed of chert, feldspar, and minor glauconite. Dark-gray wellless than 1.25 ft thick are not displayed). (167) Sandstone, medium-gray, fine-grained, thin beds in upper part, rounded chert pebbles form local layers as much as 5 cm thick. **475** ----, , 1450 - | 1 1 1 1 medium beds in lower part, quartz— and chert—rich "salt—and— OArrows at left margin of each graphic section represent center of rock 166-167 Local tool marks, oscillatory ripple marks, worm trails. D7412 unit and correspond to unit number in "sample identification" column. Arrows (32) Sandstone, gray-brown, fine-grained, thick-bedded, argillaceous; (166) Sandstone, olive-gray, fine-grained, thin-bedded, crossbedded. (273) Sandstone, gray—green, fine— to medium—grained, clayey, quartz, feldspar, chert, glauconite. Planar layering in uppermost accompanied by a number with a prefix of "D" (for example, D12918) denote a D12922> → carbonaceous, burrowed, rubbly weathering. part of bed; massive—appearing main part of bed locally shows U.S. Geological Survey Mesozoic fossil locality (for mollusks) or paleobotany D6806> crossbeds. Uppermost part of bed cut into lower part. Lenticular. (272) Shale, dark-gray, coaly, poorly exposed. (163) Sandstone, olive-gray, fine-grained, thin-bedded, crossbedded, locality (for palynomorphs), and correspond to number in species list shown in (271) Sandstone, medium-gray to olive-green in upper part, thin-, (31) Mudstone, light-gray, weathers olive-gray; silty, and locally 1 1 1 2450 — 1111 bedded, noncalcareous. fissile. Minor interbeds of thin-bedded sandstone in uppermost ııı 500 - | (29) Sandstone and mudstone, interbedded, dark-gray, thin-bedded. (28) Sandstone, olive-brown, fine-grained; upper part, plane-bedded, 111 50finely laminated; capped by wavy crosslaminated paper—thin silty layers; lower part, massive. Quartz, minor chert. 2475 — (27) Mudstone, dark-olive-gray. (268) Sandstone, gray to olive-green, fine- to medium-grained, ı ı 1500 quartz— and chert-rich "salt-and-pepper;" wood fragments; 1 1 1 1 (161) Sandstone, light-gray, fine- to medium-grained, non-calcareous, structurally deformed. composed of quartz and chert. Upper part is massive. Lower part (267) Mudstone, gray, chippy; and thin interbeds of sandstone, contains trough crossbeds, axial trend 360°, plunge 50°; parting gray, fine-grained, "salt-and-pepper. lineation trends 160°-340°. Forms ledge. (265) Sandstone, gray-green, fine— to medium-grained, 1-cm-thick beds, trough crossbeds; wood fragments. 1 1 1 2500 1 1 1 1 1525 -1 1 1 1 550 — 1 1 1 1 (25) Sandstone, olive-brown, medium-grained, medium-bedded, very D12923 ➤ → calcareous, quartz— and chert-rich "salt-and-pepper." Abundant 100 — debris of megafossils. D13062 (158) Mudstone, olive-green; minor olive-gray fine-grained sandstone. 2525 ---MOUNT EVERTS SECTION (24) Mudstone, dark-gray, fissile, poorly exposed 575 — 175 (264) Covered. Float of medium-gray limestone bed. Slope contains ı ı ı 1550 - | 1 1 1 1 (157) Sandstone. Uppermost layers are olive—brown, muddy. Remainder Geographic coordinates: lat 44°57′37" N., long 110°40′30" W. is olive-gray, fine-grained, thin-bedded, calcareous, quartz- and slickensides. Small anticline to west. Fault inferred to lie (No section, township, and range grid system present.) chert-rich "salt-and-pepper"; broad trough crossbeds. (23) Sandstone, medium-gray, fine-grained, tuffaceous, thin-bedded, D6804> --- 475 concealed in this interval; strata are not repeated but unknown if Mammoth 7.5-minute quadrangle, Yellowstone National Park, Wyoming. (22) Shale, dark-gray, slightly fissile, carbonaceous. (156) Mudstone, olive-green; minor thin siltstone layers. Poorly (21) Sandstone, yellowish-brown, fine-grained, thin-bedded, (155) Sandstone, olive-gray, fine-grained, thin-bedded, finely (19, 18) Sandstone, thick bed. Upper part, light-gray, fine- to IDENTIFICATION FEET/METERS LITHOLOGY DESCRIPTION D11927**>→** 1575 laminated, calcareous, low-angle trough crossbeds. medium-grained, well sorted; quartz-rich, minor feldspar and chert; 1 1 1 1 silicified; local burrows filled with carbonaceous mudstone. Finely laminated wavy and planar layers. Lower part, dark-gray, (37) Mudstone, dark-gray, thin-bedded, carbonaceous. (263) Siltstone, olive-green, moderately calcareous. massive, hematitic, fossiliferous. 1 1 1 150 ---(153) Sandstone, olive-gray, very fine grained. (17) Sandstone, light-gray, fine-grained, well-sorted; mainly quartz (36) Sandstone and conglomerate. Conglomerate in uppermost few and feldspar. Thin (1-10 cm), platy tabular beds, finely laminated; D11920,1> (262) Mudstone, olive-green and gray. (152-150) Mudstone, gray and olive-green, carbonaceous. centimeters of unit; clast-supported, well-rounded gray chert slightly calcareous; local crossbeds with dips of 2°-3°. D13063**▶**→₩ pebbles, medium-gray. Sandstone, medium-gray, fine- to (16) Siltstone, pale-green, silicified, carbonaceous, poorly exposed. (261) Siltstone, olive-green. medium-grained, thin-bedded, finely laminated, quartz- and 1111600 → 1111 → (15) Siltstone, dark-gray, thin-bedded, carbonaceous. (148) Mudstone, olive-green. chert-rich, glauconitic; interbeds of medium-gray mudstone. (147) Sandstone, olive-gray, fine-grained, thin-bedded, biotitic, (35) Tuff, porcellanitic, white, pink, pale-green, aphanitic, (23) Sandstone and mudstone, interbedded. Sandstone, gray, fine-(145) Sandstone, medium-gray, fine-grained, thin-bedded (1-2 cm thin—bedded. Lithophysae up to 0.5 cm diameter. (34) Sandstone, light—gray, fine— to medium—grained, thin— to arained, calcareous, quartz-rich, a few broad low-angle trough (260) Siltstone, olive-green; thin interbeds of sandstone, thick), calcareous, quartz- and chert-rich "salt-and-pepper;" local crossbeds; plant debris on beds. Mudstone, gray, very carbonaceous. light-gray, calcareous, "salt-and-pepper." shaly partings; interbedded olive-green mudstone and plant fragments medium-bedded, plane bedded; quartz, chert, feldspar. Mudstone (22) Mudstone, olive-green in lower part, gray in upper part. in lower part. Upper 0.5 m is clayey, plane bedded to undulatory; (14) Tuff, light— to medium-gray, porcellanitic, very finely lenses 1—5 cm thick and 5—20 cm long in upper part. Forms ledge. 1 1 2600 remainder is gently trough crossbedded. Forms massive outcrop. 1 1 1 1 (21) Sandstone and mudstone. Sandstone, medium-gray, fine-grained, laminated. Weathers into pencil—shaped fragments. D6773-B➤→ (32) Sandstone, medium-gray, thin-bedded. Thin interbeds of well-cemented, finely layered, very calcareous; surfaces contain (144) Mudstone, dark-gray, carbonaceous. , , , 650 - | , , , , , pale-yellowish-gray bentonite. 111 50 carbonized plant debris; horizontal burrows on surfaces and within (259) Limestone, dark-gray, thin-bedded, poorly exposed. sandstone; upper part rippled. Mudstone, dark-gray to olive-gray. (142) Mudstone, dark-gray, carbonaceous. (31) Siltstone and mudstone, interlayered thin beds, dark-gray, D12354 (20) Mudstone, dark-gray, fossiliferous. ,,, 200 — ,,,, (256) Sandstone, olive-green, very fine grained, to silty at top, (19) Sandstone, medium-gray, fine— to medium-grained, thin-bedded, D6799-B**➤** (30) Siltstone, dark-gray, thin-bedded, carbonaceous to coaly; well—cemented, very calcareous, volcaniclastic; a few shaly 2625 --- -- 800 gartings: contains some carbonized plant debris, sand-sized minor siliceous mudstone. fragments of coal, and casts of plant stems in growth position (255) Mudstone, olive-green, weathers into chips. ı ı ı 1650 - | 675 — (139) Mudstone, olive-green, weathers into chips. (13) Tuff, pale-green, porcellanitic, massive, forms ledge; 139-138 | | | | | →|^^ (138) Mudstone, dark-gray, very carbonaceous. (18) Mudstone, olive-gray, locally fissile. Minor interbeds of (253) Sandstone, gray-brown, fine- to medium-grained, thin-bedded, (28) Bentonite, pale-yellowish-gray. siltstone to fine-grained sandstone, thin-bedded, calcareous, (137) Sandstone, medium-gray, fine— to medium-grained, very very calcareous, some ripples. calcareous; weathers into 1— to 2—cm—thick beds; plane bedded and a carbonaceous to coaly. Poorly exposed. (26) Bentonite, light-gray, "popcorn"-weathering texture. few trough crossbeds; local shaly partings. (24) Bentonite, light-gray, "popcorn"-weathering texture. (251) Siltstone, dark-gray, calcareous; lenses of limestone, 1 1 2650 1 1 1 1 dark-gray, nodular, aphanitic, hard. (21) Tuff, porcellanitic, medium—gray, thin—bedded. 700 — (19) Sandstone and siltstone, interbedded, dark-gray. Sandstone, (249) Mudstone, olive-green. 1 1 1 1 100 — 1111 very fine grained, thin—bedded. (18) Siltstone and mudstone, thin—bedded, rubbly. Siltstone forms (247) Sandstone, light-gray, fine-grained, thin-bedded, very dark-gray, knobby, oval-shaped, concretion-like structures a few calcareous, quartz— and chert—rich "salt—and—pepper;" clayey in , , , , 250 — , , , , , centimeters across; internally finely laminated, lower part, which also contains wood fragments. Ripples in noncalcareous, carbonaceous. Mudstone is medium-gray, 2675 carbonaceous. 16) Sandstone, medium—gray, medium—grained, thick—bedded, (241) Sandstone, medium-gray, fine- to medium-grained, thin- to 1 | 1 | 1700 — | | | | | | medium-bedded, rippled, very calcareous, wood fragments. (134) Mudstone, olive-gray. top 1 m is trough crossbedded. (15) Sandstone and shale, interbedded, medium-gray. Sandstone, (240) Mudstone, olive-green. (133) Sandstone, olive-gray, fine-grained, 1- to 4-cm-thick beds; rippled beds 1-3 cm thick. Shale, layers a few millimeters thick. bedding surfaces are muddy, biotitic, and carbonaceous. D6799-A➤ (14) Sandstone, medium-gray, fine-grained, medium-bedded, (239) Sandstone, siltstone, and mudstone, interbedded. Sandstone, 275 glauconitic, quartz— and chert—rich "salt—and—pepper;" some (11) Tuff, light-gray. olive-green, fine- to medium-bedded, noncalcareous, locally rippled, carbonaceous debris; burrowed. Load casts at base. (10) Mudstone, dark-gray, thin-bedded. A few thin interbeds of thin-bedded; forms units about 0.5 m thick. Siltstone and mudstone, (131) Mudstone, olive-green. (13) Sandstone, yellowish-gray, fine-grained, thick bed; quartz-1 1 2700 olive-green, carbonaceous, weather into chips; horizontal burrows. 1 1 1 1 light-gray bentonite. rich. lesser chert, and feldspar, minor glauconite, noncalcareous (9) Tuff, light-gray. (238) Sandstone, gray-brown, fine-grained, thin-bedded, calcareous. (130) Sandstone, olive-gray to gray, fine-grained, "salt-and-111 750 - ww - 1 1 1 1 burrowed, probably Ophiomorpha. - 825 (8) Siltstone and clayey siltstone, dark-gray, thin-bedded, ripple ı ı ı ı 150 — 1 1 1 1 (12) Sandstone, light—brown, fine—grained, thin—bedded, basal (129) Sandstone to siltstone, dark-gray, muddy, rubbly, biotitic, part is bulbous (load casts). (10) Sandstone yellowish-gray, fine-grained, thick-bedded. Unit (6) Siltstone and clayey siltstone, dark-gray, thin-bedded, finely plant fragments. (16) Sandstone, dark-gray, fine- to medium-grained, thin-bedded, (237) Sandstone, siltstone, and mudstone, interbedded. Sandstone, 1 1 300 D6950➤→₩₩₩₩ forms base of cliff. 6) Sandstone, burrowed. (127) Sandstone, medium-gray, fine- to medium-grained, 1- to 2-cmnoncalcareous, quartz— and chert—rich "salt—and—pepper," (5) Sandstone, medium-gray, fine— to medium-grained, clayey, olive-green, fine- to medium-grained, noncalcareous, rippled, thinthick beds, quartz— and chert-rich "salt-and-pepper," broad trough noncalcareous; thoroughly bioturbated; generally massive appearing Sandstone, medium-gray. Upper part is plane bedded, bedded; forms units about 0.5 m thick. Siltstone and mudstone, (15) Mudstone, olive-green, poorly exposed. but remnant patches of fine lamination. Upper part is well thin-bedded. Lower part is trough crossbedded; Ophiamorpha olive-green, carbonaceous, clayey, form chips; horizontal burrows. indurated, contains Ophiomorpha burrows. (14) Sandstone, light-gray, fine-grained, mainly quartz, chert, and trace fossils at high angle to bedding. | | 1750 — | | | | | (4) Sandstone, medium-gray, very fine grained to medium-grained, feldspar, 25-cm-thick beds; sheared. Sandstone, thin— to medium—bedded. (236) Sandstone, medium-gray, fine- to medium-grained, very (125) Sandstone, medium-gray, fine- to medium-grained, thin-bedded, thin-bedded; clayey, poorly sorted, bioturbated, poorly indurated. (2) Sandstone and siltstone, interlayered, olive-gray to darkcalcareous, composed of quartz, chert, and feldspar; forms massive quartz— and chert-rich "salt-and-pepper," calcareous; trough (3) Sandstone, light-gray, fine-grained, medium-bedded, well sorted, gray, thin-bedded, noncalcareous, quartz- and chert-rich. outcrop but weathers into layers 2-3 cm thick; trough crossbeds quartz, chert, glauconite; locally silicified; trough crossbeds. Sandstone is fine-grained to very fine grained, finely present in most of unit, strike of axial plunge is 130°. Thickness (13) Mudstone and siltstone, interbedded. Cyclical repetition of laminated, carbonaceous; minor laminae of carbonaceous mudstone. of unit is irregular along outcrop. (1) Sandstone, greenish-gray, fine-grained, thin- to medium-bedded, from, top to bottom: olive-gray very fine grained sandstone, olive-(1) Sandstone, medium-gray, fine-grained, thick-bedded, (235) Mudstone, siltstone, and sandstone, interbedded, darkplane beds and a few trough crossbeds; calcareous, quartz, chert, gray mudstone, dark-gray mudstone that weathers to chips, olive-green quartz— and chert—rich "salt—and—pepper," muddy. Forms ledge. gray. Mudstone and siltstone, clayey, woody, poorly exposed. 1 2750 glauconite. Thin interbeds of mudstone, dark-gray, carbonaceous (124) Mudstone and sandstone, interbedded, poorly exposed. mudstone. Olive-green mudstone dominant. Intermittent exposures. D6805➤→ 1775 — (234) Sandstone, alive-gray, fine-grained, very calcareous, small (0) Siltstone, medium— to dark—gray, thin—bedded, finely trough crossbeds, sharp basal contact laminated, carbonaceous. (123) Sandstone, gray, very fine grained, muddy, "salt—and—pepper," 1 1 350 — 1 1 1 1 thin-bedded, carbonaceous bedding surfaces. 121-122 1111 1111 (122) Mudstone, gray, calcareous, carbonaceous; includes some coaly (120) Sandstone, gray-yellow, fine-grained, 1- to 2-cm-thick beds, "salt-and-pepper;" upper half is plane bedded to ripply bedded. , , 1800 - | 1111 (0) Mudstone and minor siltstone, interbedded, dark-gray, thinbedded, carbonaceous, slope-forming. (119) Mudstone, gray, carbonaceous, forms chips; poorly exposed. (12) Sandstone, light-gray, fine-grained, thin-bedded, noncalcareous; 90 percent quartz, chert; disseminated organic (118) Mudstone and sandstone, interbedded. Mudstone, olive-green. debris; coaly partings on bedding planes. Sandstone, olive-gray, very fine grained, clayey, carbonaceous, plant D6773-A➤→ 11) Sandstone. Upper part is medium-gray, very fine grained. fragments, finely laminated; about 15 percent of unit. 1 1 1 1 calcareous, faintly ripple—laminated; less common interlayers and 1825 partings of siltstone and clayey siltstone, finely laminated, 1 1 1 1 850 — 1 1 1 1 calcareous; biotite and lignitic floral traces present on bedding planes. Lower part is medium-gray, coarse-grained except for →<u>m — 7</u> (117) Mudstone, dark-gray, carbonaceous. fine grain size in uppermost strata; thick-bedded, noncalcareous, quartz— and chert—rich "salt—and—pepper;" coaly partings; trough (116) Sandstone, gray, fine-grained, 1- to 2-cm-thick beds, plant (9) Mudstone, dark—gray. fragments, ripple crosslaminations, poorly exposed. (8) Sandstone, light-gray, fine-grained, medium-bedded, hard, noncalcareous, composed mainly of quartz and 15-20 percent chert. (115) Mudstone, olive-green. Contains minor plant debris and a few silty to clayey partings. (114) Sandstone, olive-gray, very fine grained, 1- to 4-cm-thick CORRELATION CHART OF FRONTIER FORMATION FROM GREENHORN RANGE, SOUTHWESTERN MONTANA, finely laminated, muddy, carbonaceous, plant fragments. (113) Mudstone, olive-green. (227) Sandstone, medium-gray, fine- to coarse-grained, "salt-and-(112) Sandstone. Upper few centimeters is olive-gray, silty, pepper," noncalcareous, composed mainly of quartz and some chert; 112 , , 2850 TO MOUNT EVERTS IN YELLOWSTONE NATIONAL PARK, WYOMING 1 1 1 1 clayey, plane-bedded. Remainder is medium-gray, fine- to mediumtrough crossbeds throughout; lowermost part contains mud chips. grained, massive but locally weathers into beds 1-2 cm thick, quartz-Linear sole mark oriented 160°-340°. Sharp lower contact cuts and chert-rich "salt-and-pepper," trough crossbedded. Lower part contains a few current-ripple marks. (226) Siltstone and mudstone, interbedded, olive-green. (111) Coal, silty and muddy. (225) Mudstone, dark-gray, carbonaceous. (110) Mudstone, dark-gray, carbonaceous. (4) Sandstone, medium-gray, medium- to coarse-grained, noncalcareous, quartz—and chert—rich "salt—and—pepper;" local (224) Coal. (109) Mudstone, olive-green. Manuscript approved for publication December 13, 1989 chert pebbles; abrupt changes in grain size. One bed has root R.G. Tysdal, T.S. Dyman, D.J. Nichols, and W.A. Cobban (108) Mudstone and siltstone, interbedded, olive-green, rubbly. (223) Mudstone, olive-green. 2875 fragments or branch on surface. A 2-cm-thick coal seam present in (222) Mudstone and sandstone, olive-green, interbedded. upper part. A few trough crossbeds; local parting lineations; INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1990 (106) Sandstone, dark-gray, very fine grained, thin-bedded, 1 1900 -1111 orms massive outcrop. Some slickensides. (221) Sandstone, olive-brown, carbonaceous, plant fragments. noncalcareous, carbonaceous, clayey and rubbly in upper part. For sale by U.S. Geological Survey Map Distributio Box 25286, Federal Center, Denver, CO 80225 (220) Mudstone, siltstone, and sandstone, interbedded, olive-green, (2) Sandstone, medium-gray, medium- to coarse-grained, nonpoorly exposed. D6801 ➤ → mm mm calcareous, quartz- and chert-rich, "salt-and-pepper." A few

(1) Mudstone, dark-gray, siliceous, weathers into chips.